PCT
WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 5 : G01D 5/26, G01B 11/00, 11/30

A1

(11) International Publication Number: WO 93/25866

(43) International Publication Date: 23 December 1993 (23.12.93)

(21) International Application Number: PCT/AU93/00259

(22) International Filing Date: 2 June 1993 (02.06.93)

(30) Priority data:
PL 2788 5 June 1992 (05.06.92) AU

(71) Applicant *(for all designated States except US)*: MONASH UNIVERSITY [AU/AU]; Wellington Road, Clayton, VIC 3168 (AU).

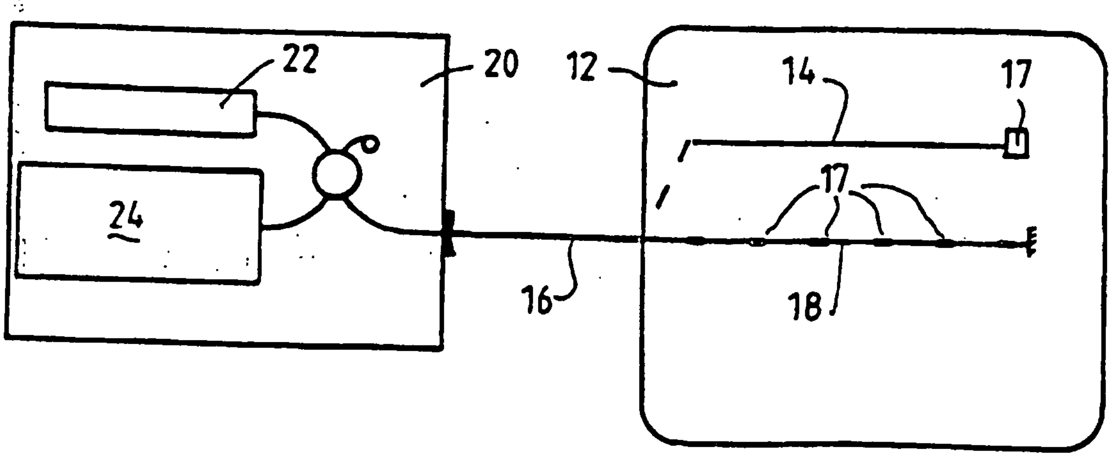
(72) Inventor; and
(75) Inventor/Applicant *(for US only)* : TAPANES, Edward, Eduardovich [CA/AU]; 12 Delos Street, South Oakleigh, VIC 3167 (AU).

(74) Agent: WILSON, Stephen, Henry; Griffith Hack & Co., 509 St. Kilda Road, Melbourne, VIC 3004 (AU).

(81) Designated States: AU, CA, JP, KR, NZ, US, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

Published
With international search report.

(54) Title: SENSING PATCHES UTILISING INCORPORATED WAVEGUIDE SENSOR



(57) Abstract

A sensing patch is disclosed which has a body (12) formed from a suitable host material and which is shaped to form a patch which can be adhered or otherwise attached to a structure. A waveguide which may be in the form of an optical fibre (14) or an optical fibre in combination with a sensor element (17) is embedded in the host material forming the body (12). When a change in a parameter of the structure takes place a property or characteristic of electromagnetic radiation propagating in the waveguide sensor is altered by the change in that parameter to thereby provide an indication of the change in the parameter. Thus, the sensing patch monitors the change in parameter in a manner which does not destroy the patch.

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AT	Austria
AU	Australia
BB	Barbados
BE	Belgium
BF	Burkina Faso
BG	Bulgaria
BJ	Benin
BR	Brazil
CA	Canada
CF	Central African Republic
CG	Congo
CH	Switzerland
CI	Côte d'Ivoire
CM	Cameroon
CS	Czechoslovakia
CZ	Czech Republic
DE	Germany
DK	Denmark
ES	Spain
FI	Finland
FR	France
GA	Gabon
GB	United Kingdom
GN	Guinea
GR	Greece
HU	Hungary
IE	Ireland
IT	Italy
JP	Japan
KP	Democratic People's Republic of Korea
KR	Republic of Korea
KZ	Kazakhstan
LI	Liechtenstein
LK	Sri Lanka
LU	Luxembourg
MC	Monaco
MG	Madagascar
ML	Mali
MN	Mongolia
MR	Mauritania
MW	Malawi
NL	Netherlands
NO	Norway
NZ	New Zealand
PL	Poland
PT	Portugal
RO	Romania
RU	Russian Federation
SD	Sudan
SE	Sweden
SK	Slovak Republic
SN	Senegal
SU	Soviet Union
TD	Chad
TG	Togo
UA	Ukraine
US	United States of America
VN	Viet Nam

SENSING PATCHES UTILISING INCORPORATED WAVEGUIDE SENSOR

This invention relates to a sensing patch for monitoring engineering structures and fabricated items.

Engineering structures and fabricated items are usually not monitored in real-time due to the difficulties in connecting conventional sensors to them and because of the limitations of the sensors. This is particularly so when dealing with metallic structures. In the case of structural integrity monitoring, visual and nondestructive evaluation techniques are required at frequent intervals and often prior disassembly is required. This is a very time consuming and costly exercise. The ability of a sensor to continuously monitor structures in real-time and would therefore provide significant cost savings and would improve safety by constantly monitoring the state of the structure. Hitherto, it has not been clear how sensors can be applied to existing metallic structures, nor built into the present manufacturing processes of structures.

The object of the present invention is to provide a sensor monitoring method which overcome this problem.

The invention may be said to reside in a sensing patch for monitoring an engineering structure or fabricated item comprising:

a patch body formed from a host material;

a waveguide sensor embedded in or surface adhered to the patch body; and

wherein in use, the sensing patch is attached to the structure or item so that a property or characteristic of electromagnetic radiation propagated in the waveguide sensor is altered by a change in a parameter of the structure or item which is to be monitored, and wherein the

electromagnetic radiation is detected so that the change in property or characteristic provides an indication of a change in the parameter of the structure or item.

The invention may also be said to reside in a method of monitoring a structure or fabricated item comprising the steps of:

attaching a sensor comprising a patch body formed from a host material and a waveguide sensor embedded in or surface adhered to the patch body, to the structure or fabricated item such that the waveguide sensor is not exposed to the outer environment;

detecting electromagnetic radiation propagating in the waveguide sensor and utilising properties and characteristics of the detected electromagnetic radiation to monitor a desired parameter of the structure or fabricated item.

The two significant difficulties which need to be resolved before optical fibre sensors are utilised in structural integrity monitoring applications are overcome by the present invention. First, nearly all existing structures and a large proportion of future structures are made of materials (ie metals) which make embedding the sensors quite difficult. In addition, surface adhering the sensors is unreliable and renders the sensors susceptible to contact damage. Secondly, components with embedded sensors need to be connected to form the final structure (ie the wing of a composite material aircraft), but there are tremendous difficulties in reliably connecting the sensor networks from component to component. The sensing patch overcomes these difficulties because the sensors are incorporated in a compatible material which can be adhered to any surface of the structure.

The concept of incorporating waveguide sensors into a patch body allows the patch body to be adhered to the surface of existing/completed structures. Thus, the sensor according

to this invention can be used in real-time and in-situ in order to monitor engineering structures and fabricated items. Utilisation of properties and characteristics of the electromagnetic radiation propagating in the waveguide sensor also enables monitoring to take place in a non destructive manner. Thus, the sensor is not destroyed in order to monitor the desired parameter.

Preferably the host material from which the patch body is formed is carefully selected to suit the environment of application (ie hot, cold, dry, wet, etc). The effective sensing length of the waveguide used can be varied for either point or integrated sensitivity. Multi-point and parameter-field sensing can be achieved by quasi-distributed, distributed or multiplex configurations. In addition, the sensor may contain components which actively respond to certain events or perturbations in the host body, for example: shape memory alloys, piezo-electrics, electro-rheological fluids, and other intelligent materials.

The patch body can be configured to any desired shape and size and can be adhered to any surface by means of an appropriate adhesive, clamp, or any other holding device. The location could be a critical area, an area that is difficult to reach, or an area where existing defects (ie, cracks, corrosion, debonding etc) need to be carefully monitored.

Preferably the waveguide is embedded in the patch body and this provides the added advantage of protecting the sensor from the environment and from contact damage.

Preferably the waveguide comprises at least one optical fibre and/or at least one optical fibre device. In some embodiments of the invention the waveguide may merely comprise an optical fibre without any additional sensing elements. However, the optical fibre can include sensing elements at its end or along its length and those sensing

elements can comprise devices which will respond to a change in the desired parameter of the structure or facility and influence the properties and characteristics of the electromagnetic radiation propagating in the waveguide to thereby provide and indication of the change in the parameter. The sensing elements can include etching on the optical fibre or other physical changes to the optical fibre or devices to which the optical fibre is connected.

The optical fibre may be a single-point optical fibre, quasi-distributed optical fibres, distributed optical fibres, multiplexed-demultiplexed optical fibres. The waveguide or waveguides may be formed from any waveguiding material including sol-gel glass, polymeric material or may be any form of monolithic substrate. Electro-optic devices, integrated optical devices or magneto-optic devices may also be utilised.

Preferably instrumentation is provided for coupling to the sensing patch for receiving electromagnetic radiation from the waveguide sensor and for detecting the property or characteristic of the electromagnetic radiation to provide an indication of any change in the parameter which is to be monitored.

Preferred embodiments of the invention will be described, by way of example, with reference to the accompanying drawings in which:

Figure 1 is a view showing embodiments of the invention;

Figure 2 is a view showing further embodiments; and

Figure 3 is a view showing still further embodiments of the invention.

With reference to figure 1 a sensor 10 according to the preferred embodiment comprises a patch body 12 formed from a suitable host material and which is shaped to form a patch which can be adhered to an engineering structure or

manufactured article. A single point sensor element 14 in the form of a single optical fibre is embedded in the host body 12 and is connected to an optical fibre patch cord 16. Alternatively, a quasi-distributed multi-point optical fibre 18 could be embedded in the patch body 12.

The optical fibre patch cord 16 is coupled to instrumentation 20 which includes a light source 22 and a detector and signal processing unit 24.

The light source 22 provides light which is propagated along the optical fibre 14 or 18 and, which in the embodiment of figure 1, is reflected back along the optical fibre for detection by the unit 24. However, in other embodiments the detecting unit 24 could be located at the end of the optical fibre and the transmitted wave could merely be detected by the unit 24 without the need for reflection.

The propagated light which is detected by the unit 24 has its properties and characteristics altered by a change in an associated parameter which is to be monitored. In some embodiments an occurrence or change in a parameter acting on the patch body 12, and therefore the optical fibre, is sufficient to cause a change in the property or characteristic of the propagated electromagnetic radiation which can be detected by the unit 24. However, in other embodiments a single sensor element 17 in the case of the single point element 14 can be connected to the fibre so that the change in the parameter influences the element 17 which in turn influences the nature of the wave propagating in the fibre 14. The element 17 can be a device to which the optical fibre 14 is connected or the optical fibre 14 could be etched or otherwise have its physical characteristics changed so that electromagnetic radiation propagating in the fibre 14 will have its properties and characteristics changed in accordance with the change in the desired parameter.

In the case of the multi-point optical fibre 18 a

plurality of elements 17 are arranged along the length of the fibre 18.

In the embodiment of figure 2 an active control element 26 is incorporated together with the single point optical fibre 14 or the multi-point optical fibre 18. A cable 28 couples the active control element 26 to the detector and signal processing unit 24.

In the embodiment of figure 3 multiplexed and quasi-distributed multi-point optical fibres 30 are embedded in the patch body 12. A (1xN) star coupler 32 joins the optical fibres 30 to one single optical fibre in the instrumentation unit 20. This type of configuration would be capable of mapping parameter fields.

In the preferred embodiment the optical fibres 14, 18 and 30 are embedded in the patch body 12. However, in some embodiments the optical fibres may be surface adhered to the patch body 12. If the optical fibres 14, 18 and 30 are surface adhered to the patch body 12 it is preferred that when attaching the patch body 12 to a structure or item the patch body 12 be attached such that the optical fibres 30 are sandwiched between the structure or item and the patch body 12 so that the optical fibres are therefore protected from the environment.

A primary application of the sensor according to the preferred embodiments of this invention is in structural integrity monitoring. The sensor can be used to monitor a wide variety of structures, for example: metal/composite aerospace structures, satellites, marine and storage vessels, off-shore oil rigs, submersible vessels, pipelines, chemical storage containers, power transformers, buildings, bridges, structures which require high security and surveillance etc. Other parameters could also be monitored depending on the type of waveguide and sensor elements employed.

The sensors are configured such that they are capable

of monitoring parameters in a reliable and reputable manner. In other words, the sensor material does not rely on failure, fracture, breakage, or any other form of permanent, irreversible change. The sensors utilise the properties and characteristics of the electro-magnetic wave propagating in the wave guiding material to monitor the desired parameters. For example, change in phase, intensity, frequency or the like of light propagating in the waveguide can be used to monitor changes is parameters of a structure such as integrity, stress, temperature and the like. Indeed, the following parameters are capable of being monitored by means of an appropriate waveguide and sensor element(s).

temperature	chemicals
pressure	material curing
strain	corrosion
vibration	liquid levels
frequency	electric fields
damage	magnetic fields
impact	current
displacement	voltage
deformation	orientation
acoustic waves	acceleration
microwaves	position

Examples of environments in which the preferred embodiments of the invention can be utilised and which highlight the advantages offered by the sensor of the preferred embodiments are as follows:

Aerospace structures operate on extremely tight tolerances and safety criteria. As a consequence, aerospace structures are often inspected at frequent intervals using labour intensive non-destructive techniques. Electrical strain gauges and piezo-electrics cannot be incorporated into

the structure without detrimental effects and have a limited fatigue life. As a consequence, real-time structural integrity monitoring is rarely achieved in aerospace structures, except perhaps in sophisticated military research projects. Optical fibre sensing patches, alternatively, can be adhered to the inner-surface of aerospace structures, thus not affecting the aerodynamics, and yet provide the following advantages over conventional sensors: they can perform either static or dynamic measurements, are capable of residual strain measurements, they have very high fatigue life, are corrosion resistant, are non-conductive, are capable of point or distributed sensing, can be configured to any shape or contour, and a single sensor is capable of monitoring several parameters simultaneously. Furthermore, directly embedding the optical sensor in composite components raises a significant issue of connectorisation of the optical sensor from component to component, whereas the sensing patch has the advantage of coupling the cable emerging from the patch to the existing cable assembly of the structure.

Off-shore oil rigs are generally routinely inspected for structural integrity by divers or robots. The harsh, corrosive environment renders it nearly impractical to attach conventional sensors to the structure. As a result, cracks or any other form of damage cannot be detected in its early stages and could possibly grow to within catastrophic levels before it is visually found. Electrical strain gauges would require long wire-lead lengths to reach the desired sensing region, thus electrical noise would be a large limitation. Piezo-electric sensors have a major limitation in that they are a dynamic material, whereas vibrations in oil rigs are generally quasi-static (< 2 Hz). In addition, electrical devices are prone to corrosion damage which would limit their lifetime substantially. Optical sensing patches are not only resistant to corrosion, but they could monitor

the extent of corrosion of the structure. Lightning strikes would severely effect electrical/conductive devices, whereas optical sensors are generally not affected by this type of strike. The optical sensing patch can be reliably adhered to critical areas of off-shore oil rigs (ie underwater support structures) and thus offers the opportunity to monitor the structural integrity in real-time.

Naval vessels (ships or submersibles) are generally monitored by divers or in dry docks for structural integrity. The limitations of conventional sensors in this case are the same as those discussed for off-shore oil rigs. Optical sensing patches would be extremely useful for these structures. A particular advantage of an optical sensing patch for use in these structures is the ability to monitor relatively large areas. Conventional sensors are usually limited in size. The longer/larger sensor types that do exist are usually very expensive. The optical sensing patch, on the other hand, can be configured to any desired length/size with only a marginal increase in cost and complexity. This can be achieved by incorporating optical sensor arrays or distributed sensors in the patch material.

Power stations and transformers are critical structures to monitor as they tend to over-heat and have vibrational problems which could result in extremely dangerous explosions. Conventional sensing techniques can suffer extreme electrical noise problems when monitoring these structures due to electro-magnetic interference (EMI). Optical sensing patches can easily be adhered to these structures to monitor temperature, vibrations, cracking, strains and stresses, and several other important parameters in real-time, without the noise limitations.

Undersea pipelines are generally not monitored at all due to the lack of any reliable and durable sensing techniques. If the pipeline is damaged in any way (ie

cracking, corrosion, etc) it is usually realised when the output is affected. Limited information may be available as to the type and location of the fault. Obviously, this is an inefficient and potentially costly situation. Not only has the flow of goods stopped, but the pipeline has to be pulled up or divers/robots need to go down to have a look for the fault. Undersea pipelines are in a very harsh and corrosive environment. In addition, their lengths can vary from a few meters to several hundred kilometres in length. Conventional conductive sensors would have difficulties surviving the environment and because of the long lengths or wire-leads required they would suffer from electrical noise problems. Undersea optical fibre communication cables have proved their capabilities in long-haul (> 1000 km) applications, therefore optical fibre sensors could be useful in long-haul sensing requirements. The sensing patch would provide the means of connecting the sensors to the structure and have the additional benefit of offering protection to the sensor.

Preferred embodiments of the invention have been tested as illustrated by the following examples. The sensors were constructed in order to determine the feasibility of embedding optical fibre sensors in composite materials and to determine if the optical fibre sensors were capable of monitoring parameters relating to structural integrity. The samples were constructed from Hercules AS4/1919 graphite/epoxy and Kevlar 49/epoxy thermoset composites as well as ICI Fiberite APC-2 graphite/PEEK thermoplastic.

Example 1

Optical fibre sensors were embedded in specimens constructed of 12 layers of unidirectional graphite/PEEK. The specimens were subjected to a pure tensile load. A maximum strain failure test was performed to determine whether the material or the embedded optical fibre sensors would fail first. The results revealed that the material

failed before the embedded sensor (at 32000 με or a load of 68kN) if the sensor was collinear to the material fibre direction. When loading specimens with the embedded optical fibre sensor at 30 degrees to the material direction, the angled sensor was found to fail before the material (at 25000 με or a load of 55 kN).

Example 2

Optical fibre sensors were bonded to the surface of metallic cantilever beams using an inviscid cyanoacrylate (Zap-CA). Electrical strain gauges were co-located with the localised optical fibre sensor to verify results. Monitoring of both static and dynamic strain and vibration in the cantilever beam was successfully accomplished.

Example 3

Optical fibre sensors were embedded in the above mentioned composite materials at various ply interfaces. The specimens were made up of sixteen plies (layers) and were mounted in a cantilever arrangement. The cantilever beams were then subjected to static strain and to vibration. Electrical strain gauges were bonded to the surface, co-located with the localised optical fibre sensor, in order to verify results. The optical fibre sensors accurately determined the applied static strain and vibrations, regardless of which interface they were embedded in. In addition, the optical fibre sensors were used to determine the through-thickness strain distribution of the composite specimens. This was the first reported measurement of the internal strain distribution of composite materials. It was only possible due to the ability of optical fibre sensors to be embedded.

Example 4

Optical fibre sensors were embedded in 12 ply Kevlar/epoxy specimens and subjected to three-point bend

loading. Acoustic emission signals were generated in the material when load-induced damage occurred. Piezo-electric sensors were bonded to the surface, co-located with the optical fibre sensor, to verify results. The optical fibre sensors accurately monitored the acoustic emission signals generated in the composite material.

Example 5

Optical fibre sensors were embedded in specimens constructed of 6 layers of unidirectional Hercules AS4 graphite/apoxy. The specimens were mounted in a cantilever arrangement. Electrical strain gauges were co-located on the surface with the localised optical fibre sensor in order to verify results. Monitoring of dynamic strain (vibration) and structural resonance was successfully accomplished and verified with the electrical strain gauges.

The same specimens were then adhered to a steel cantilever beam. A PVDF piezo-electric polymer sensor was co-located with the optical fibre sensor and electric strain gauge. Monitoring of dynamic strain (vibration) and structural resonance was successfully accomplished and verified with the electrical strain gauge and PVDF sensor. These experiments were performed as a proof-of-principles of the sensing patch.

Since modifications within the spirit and scope of the invention may readily be effected by persons skilled within the art, it is to be understood that this invention is not limited to the particular embodiment described by way of example hereinabove.

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. A sensing patch for monitoring an engineering structure of fabricated item comprising:

a patch body formed from a host material;

a waveguide sensor embedded in or surface adhered to the patch body; and

wherein in use, the sensing patch is attached to the structure or item so that a property or characteristic of electromagnetic radiation propagated in the waveguide sensor is altered by a change in a parameter of the structure or item which is to be monitored, and wherein the electromagnetic radiation is detected so that the change in property or characteristic provides an indication of a change in the parameter of the structure or item.

2. A method of monitoring a structure or fabricated item comprising the steps of:

attaching a sensor comprising a patch body formed from a host material and a waveguide sensor embedded in or surface adhered to the patch body, to the structure or fabricated item such that the waveguide sensor is not exposed to the outer environment;

detecting electromagnetic radiation propagating in the waveguide sensor and utilising properties and characteristics of the detected electromagnetic radiation to monitor a desired parameter of the structure or fabricated item.

3. The sensing patch of claim 1, wherein the host material from which the patch body is formed is selected to suit the environment of application.

4. The sensing patch of claim 1 wherein, the patch body is configured to any desired shape and size and is attached to a

surface by holding means.

5. The sensing patch of claim 1, wherein the waveguide is embedded in the patch body.

6. The sensing patch of claim 1, wherein the waveguide comprises at least one optical fibre and/or at least one optical fibre device.

7. The sensing patch of claim 6, wherein the optical fibre includes sensing elements at its end or along its length and those sensing elements comprise devices which will respond to a change in the desired parameter of the structure or facility and influence the properties and characteristics of the electromagnetic radiation propagating in the waveguide to thereby provide an indication of the change in the parameter.

8. The sensing patch of claim 6 or 7 wherein, the optical fibre is a single-point optical fibre, quasi-distributed optical fibres, distributed optical fibres, or multiplexed-demultiplexed optical fibres.

9. The sensing patch of claim 1, wherein instrumentation is provided for coupling to the sensing patch for receiving electromagnetic radiation from the waveguide sensor and for detecting the property or characteristic of the electromagnetic radiation to provide an indication of any change in the parameter which is to be monitored.

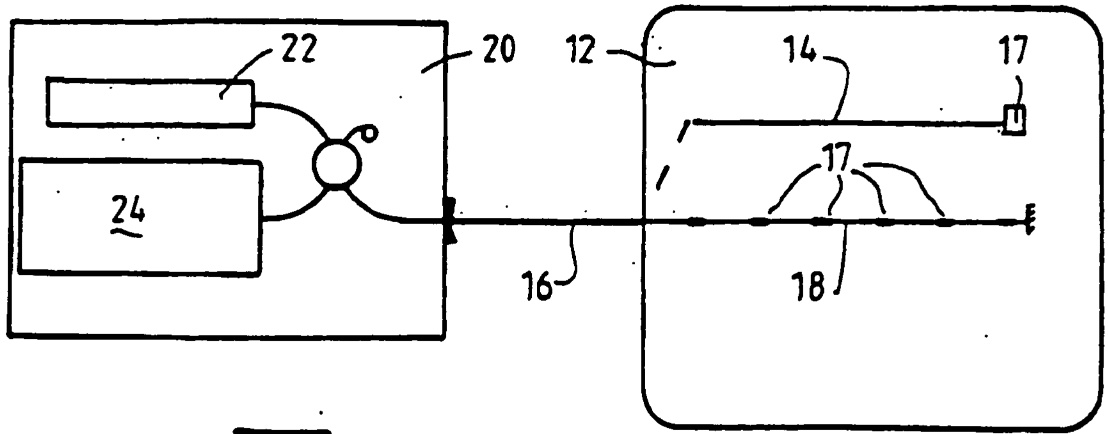


FIG. 1.

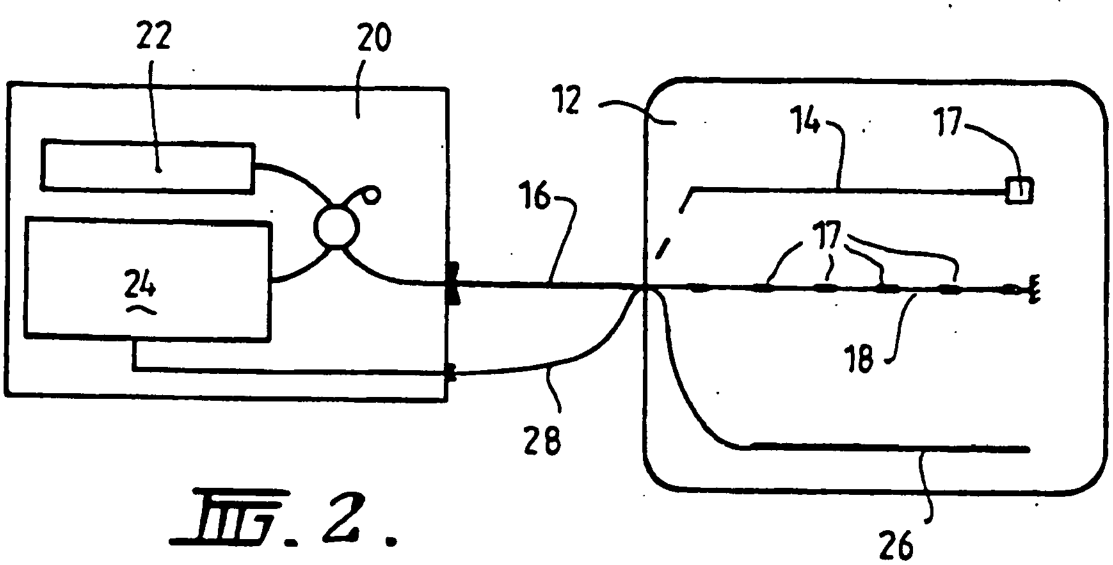


FIG. 2.

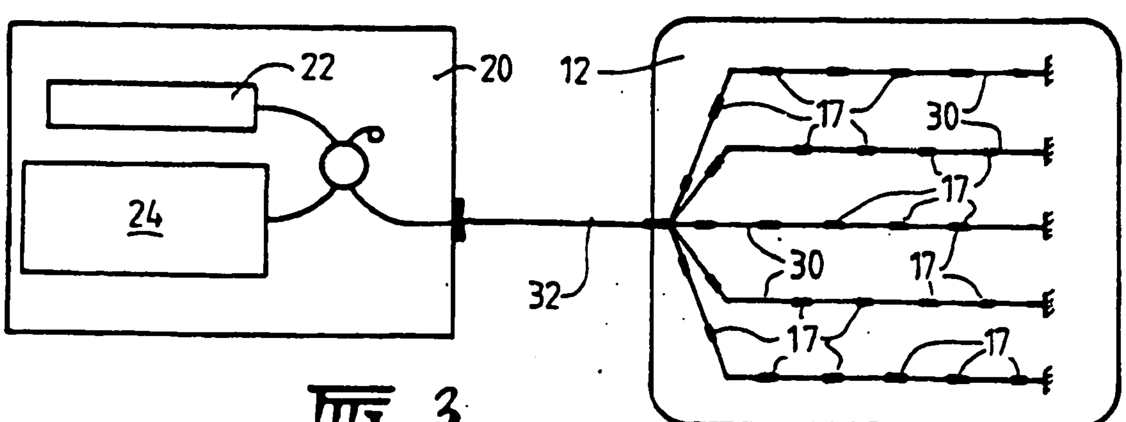


FIG. 3.

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl.[5] G01D 5/26, G01B 11/00 11/30

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC G05D 5/26, G01B 11/00 11/30

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
AU : IPC as above

Electronic data base consulted during the international search (name of data base, and where practicable, search terms used)
DERWENT : WAVEGUIDE AND OPTICAL FIBER
JAPIO : WAVEGUIDE AND OPTICAL FIBER

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to Claim No.
X	US,A, 4930852 (WHEELER et al) 5 June 1990 (05.06.90) Abstract and figure 1	1-9
X	AU,B, 68756/87 (597937) (GRIFFITHS) 18 August 1988 (18.08.88) Page 3 and figures 4 and 9	1-9
A	WO,A, 86/00988 (TELEFONAKTIEBOLAGET L M ERICSSON) 13 February 1986 (13.02.86) Abstract and figure 1	1-9

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
16 September 1993 (16.09.93)	17 SEP 1993 (17.09.93)

Name and mailing address of the ISA/AU	Authorized officer
AUSTRALIAN INDUSTRIAL PROPERTY ORGANISATION PO BOX 200 WODEN ACT 2606 AUSTRALIA Facsimile No. 06 2853929	S.PRING Telephone No. (06) 2832190

C(Continuation).	DOCUMENTS CONSIDERED TO BE RELEVANT	
Category*	Citation of document, with indication, where appropriate of the relevant passages	Relevant to Claim No.
A	EP,A, 208562 (ELDEC CORP) 14 January 1987 (14.01.87) Abstract and figure 3	1-9
P,A	Patents Abstracts of Japan, P1449, page 99, JP,A, 4-204114 (FUJIKURA LTD) 24 July 1992 (24.07.92) Abstract	1, 2

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report		Patent Family Member					
EP	208562	JP	62019715	US	4724316		
US	4930852	CA	2010447	EP	384649	IL	93467
		JP	3033244	US	5029977		
WO	8600988	AU	46367/85	CA	1265945	DE	3564618
		DK	1275/86	EP	188512	FI	860975
		JP	61502785	NO	860737	SE	8403811
		US	4795232				

END OF ANNEX